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Seed Treatment Control of Rhizoctonia in Idaho

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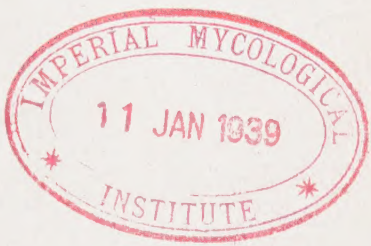

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SUMMARY

1. During the last thirty years there have been comparatively few advances made resulting in more efficient control of potato diseases by means of seed treatment.

2. Cultures of *Rhizoctonia solani* isolated from potato tubers, secured from various parts of the United States, exhibited marked differences in growth characters when grown on various culture media.

3. Under non-irrigated conditions in the Pacific Northwest sclerotia of rhizoctonia are usually hard knobby growths many times attaining the size of large garden beans. These sclerotia are characteristically different than those which appeared upon potatoes obtained from various parts of the United States.

4. There was no definite correlation between the size of sclerotia in culture and the part of the United States from which the culture was secured, when all of the cultures studied were taken into consideration.

5. There is need of more careful study of the relation of strains of rhizoctonia to the problem of potato seed treatment.

6. It has been found that presprinkling potatoes with water forty-eight hours before treatment and keeping moist during that time increased the efficiency of various treatments used.

7. The type of germination following the mercuric chloride treatment was characterized by a tuft of mycelium in the center of the inverted sclerotium, while that following the treatment with formalin and furfural was quite spreading. This difference in type of germination may have a very definite effect upon the efficiency of these treatments under field conditions.

8. Furfural did not prove to be as efficient as formalin in laboratory trials when used at the same concentrations, time of exposure and temperature.

9. Du Pont Dust No. 15 when applied to the uncut presprinkled tubers at the rate of three ounces to the bushel gave better control under field conditions than any other treatment tested.

10. Copper carbonate dust when used at the rate of three ounces to the bushel had a serious effect upon the germination of the tubers, which was noted in connection with no other treatment tested.

11. Percentage of control, as shown by the freedom of the tubers from sclerotia at digging time, can be estimated with equal accuracy by basing the percentages upon total number of tubers or upon total weight of tubers.

SEED TREATMENT CONTROL OF RHIZOCTONIA IN IDAHO

By

J. M. RAEDER, C. W. HUNGERFORD, and NAOMI CHAPMAN.

INTRODUCTION

Altho it has been 34 years since Bolley (2) first recommended the use of corrosive sublimate for potato seed treatment and over 27 years since Arthur (1) demonstrated the efficiency of formaldehyde for the control of potato scab, there have been but few other important contributions to our knowledge of potato seed disinfection. Rolfs (18) and Gussow (10) by means of field experiments and later Gloyer (9) by means of laboratory trials found that better control of rhizoctonia was secured with the corrosive sublimate method of treatment than with the cold formaldehyde method when various strengths of solution and various lengths of immersion were tested. Brann and Vaughn (4), (5) have shown that a solution of corrosive sublimate will lose strength rapidly when tubers are immersed in it and that the solution may be kept up to standard strength by the addition of definite amounts of the chemical after each lot of tubers is treated. Melhus and Gilman (15) (16) recommended the hot formaldehyde method of seed treatment which has many distinct advantages and which has become very popular. Vaughn and Brann (21) found that soaking the tubers in water for some time previous to treatment softened the sclerotia of rhizoctonia and seemed to make the treatment more effective. The authors (17) found that sprinkling the tubers with water and keeping them moist for from 24 to 48 hours started the growth of the sclerotia on their surfaces and made seed treatment much more effective.

Potato seed treatment tests as carried on by various workers have given results which are exceedingly conflicting. As an example of the contradictory results which may be secured under different conditions we may cite the report of Melhus (13) upon the cooperative seed treatment tests made by the Wisconsin, Minnesota and Iowa Experiment Stations. Different lots of seed were given three treatments, cold formaldehyde, hot formaldehyde and corrosive sublimate, at each of the different stations. These lots were than divided so that seed treated at each station was grown at all three stations. The report shows that each of the three treatments used gave the best control in at least one lot of potatoes grown at one of the three stations. Melhus and Gilman (16) have pointed out that much of the variation in results secured by various workers may be

due to lack of sufficient replications of trials and to an inadequate system of controls. They also call attention to three variable factors found in such experiments, namely, the presence after treatment of a greater or less number of viable pathogenes on the seed piece, the inhibitory rather than fungicidal action of certain chemicals used in seed treatment and the presence of the pathogene in the soil.

Variation in Rhizoctonia Solani Kuhn

In connection with the series of seed treatment studies which the writers have carried on for the last few years and which are reported in this paper, another very definite variable factor has come to light. Early in the progress of the study, it became evident that the sclerotia of *Rhizoctonia solani* which develop ordinarily on potatoes in the Pacific Northwest are much different in appearance from those usually found in the Middlewest. Plate 1, figure 1, illustrates the type of sclerotia usually found in northern Idaho. These are hard, knobby growths on the surface of the tubers, many times attaining the size of large garden beans. The diffuse type shown in plate 1, figure 2, which is the type commonly found in the Middlewest is seldom seen on tubers grown in northern Idaho. Potatoes grown under irrigation in southern Idaho may be covered with sclerotia of both types.

The moisture content of the soil, especially during the later part of growing season, as well as the character of the soil itself, without doubt, may influence materially the number as well as the character of the sclerotia formed upon potato tubers. At first, it was thought that these factors might account for the difference in sclerotial development referred to above. We have some evidence, however, which seems to indicate that different strains of rhizoctonia may produce different types of sclerotia when grown in artificial culture. Potato tubers bearing sclerotia of rhizoctonia were secured from several states and cultures were isolated from these various lots and compared upon several different media. A careful study of all of these cultures has not yet been completed, but enough work has been done to show that there are among them several distinct types of growth. Plate 11, figure 1, shows four of these cultures growing on potato dextrose agar. Note the wide variation in the size and character of the sclerotia. The same four cultures are shown in plate 11, figure 2, growing on oatmeal agar. The variation in size of sclerotia is even more marked. Culture Number 1 was secured from Iowa, Number 2 from New York and Numbers 3 and 4 from Utah. Although in these cases the cultures with diffuse growth and scant sclerotial development were from eastern states and the two with large sclerotia were from

the West, there was no definite correlation between size of sclerotia in culture and the part of the United States from which the cultures were secured, when all the cultures studied were taken into consideration.

Several workers have noticed differences in the rhizoctonia organism which might influence the results of seed treatment. Melhus and Gilman (16) state that the results may be affected by the size of the sclerotia, the compactness of the sclerotial hyphae, and the position of the sclerotia on the tubers. Duggar (7) refers to the difference in parasitism of rhizoctonia on potatoes and states that this may be partly due to climatic conditions and partly due to the pathogenicity of the particular strain of the fungus. He also states that strains exist evidence of which may persist for some time in the general appearance of the cultures.

Rosenbaum and Shapavalov (19) isolated and described a strain of rhizoctonia on potatoes which was plainly distinct from all others studied. Corsant (6) isolated a large number of strains from different localities. He reports that the cultural characters were similar, altho some variations were noted. Matsumoto (12) decided that all strains studied might be derived by growing one strain under diverse environmental conditions.

Objects of Experiments

The majority of all published data seem to indicate that in general corrosive sublimate is a more effective treating agent for the control of rhizoctonia than cold formaldehyde. The results secured by Gussow (10), Rolfs (18), Brann and Vaughan (4), and others would so indicate. Gilman and Melhus (8) found that cold formaldehyde, corrosive sublimate and hot formaldehyde were about equally efficient over a period of three years in Iowa.

The experiments which are reported in this paper were started primarily to test various methods of treatment under Idaho conditions; to find if possible, a method which would be efficient and at the same time not have the many disadvantages of the standard long-soak cold formalde and corrosive sublimate methods. The following methods of treatment have been tested:

(1). Tests of different methods of potato seed treatment in both laboratory and field.

(a). Corrosive sublimate.
(b). Cold formaldehyde.
(c). Hot formaldehyde.
(d). Cold furfural.
(e). Hot furfural.
(f). Miscellaneous dust treatments.

(2). The effect of presprinkling with water 24-48 hours before treatment upon the efficiency of the various methods of potato seed treatments used.

Methods

Laboratory.

In the laboratory, lots of three or four potatoes, showing an abundance of sclerotia were used for each treatment. The potatoes were treated in solutions contained in a small granite pail of about three liters capacity. When hot solutions were used, the temperatures were obtained directly on an electric range with the range set at "low." Potatoes immersed in such solutions were constantly agitated in order to eliminate the possibility of them coming in contact, for too long a period, with the overheated bottom of the pail. Presprinkled potatoes were thoroly wetted in running water and immediately placed in glass moist chambers to remain there for the required time. After treating in hot solutions tubers were covered for one hour. They were then allowed to dry thoroly before the sclerotia were removed and plated. As uniform sclerotia as possible were used in plating.

In testing the efficiency of the various treatments used, the sclerotia were picked from the surface of the tubers with a flamed scalpel, transferred to plates of acidulated potato agar where they were placed in an inverted position. In other words, the surface of the sclerotia adhering to the tuber was placed uppermost. Two drops of a 5 per cent solution of lactic acid were placed in each petri dish before the agar was poured. After plating the sclerotia, they were incubated for 48 hours at room temperature. Examination of the cultures was accomplished with the aid of the low power of a compound microscope.

Field.

Presprinkling was first conducted in 1921. To accomplish this, the potatoes contained in sacks, were dipped in water, thoroly agitated, removed, piled and covered for from 24 to 48 hours, depending upon the particular treatment. Every endeavor was made to keep the tubers moist during this time. The same results can be obtained by first piling the potatoes loose or in sacks, then thoroly soaking them with water from a hose. It is quite important that each tuber be wet over its entire surface. Covering for the allotted time should then follow.

Jensen (11) was probably the first to advocate the use of water as a preliminary step in the treatment of grain, when in 1887-1889 he divised and recommended a presoak of the grain to be treated with hot water. This method was later known as Jensen's modified hot water method of seed treatment for the control of smut and was first used by him for the

control of loose smut of barley. Swingle (20) later applied this method to wheat. Braun (3) in 1919 further recommends the presoak to eliminate seed injury and to increase the efficiency of both formalin and copper sulfate in the control of black chaff of wheat.

Braun and Vaughn (4) in 1921 showed that presoaking potatoes for 24 hours previous to treatment for scab control increased the efficiency of such treatments. They used corrosive sublimate in the tests. From the data they offer, however, they apparently immersed the tubers in water and permitted them to remain their for the allotted time.

Previous to 1924, the field trials were conducted on a comparatively small scale. Rather small lots of potatoes were used with sclerotia as uniform in number and size as possible. The treating of this seed was conducted in the laboratory in a similar manner as for the laboratory trials. The results of these earlier trials were based upon the percentage of tubers, by weight, showing sclerotia at digging time.

In 1924, quite extensive field trials were conducted, embracing in all 28 various treatments, including three checks. These treatments included corrosive sublimate, formalin, both hot and cold, hot furfural, copper carbonate dust, and organic mercury compounds, both dry and in solution. These treatments were compared both with and without presprinkling. In these particular trials, the hot treatments were applied in a 15-gallon galvanized can, having a false bottom. The source of heat was an electric hot-plate. The potatoes, while being treated in the tank, were constantly agitated to eliminate any possibility of overheating the tubers at the bottom of the tank. After receiving this treatment, the potatoes were removed from the solution and covered for one hour before being allowed to dry. The dry organic mercury compounds and copper carbonate dust were applied by means of a small barrel churn. The tubers and the chemicals were placed in the churn, which when closed, was turned 25 times in one direction, then reversed, and turned the same number of times. An ordinary wooden barrel was used in all other treatments. Enough tubers to furnish 300 seed pieces were used in each treatment. They were divided into three lots and were used for three replications in the field.

In recording data for the 1924 field trials, the percentages of control were based on both total weight and total number of tubers. All tubers were considered diseased if any sclerotia were found on them.

EXPERIMENTAL DATA

Laboratory Tests.

No extensive laboratory tests were made in 1920. The hot formaldehyde treatment was first tested at the Idaho Experiment Station that

year. In preliminary tests that were carried on it was found that sclerotia of rhizoctonia transferred to culture media from potatoes treated by the hot formaldehyde method grew practically as vigorously as those from untreated checks. Those treated by the standard mercuric chloride method made practically no growth.

Presprinkling was first tried in 1921. The tests were made in connection with a study of the effect of successive dippings on the strength of a mercuric chloride solution, when used in treating seed* The results of this preliminary test are given in table 1. The original solution was a 1-1000 mercuric chloride solution. Each dipping was of one and one-half hours duration.

Table 1

Germination of Sclerotia of Rhizoctonia from Tubers after Successive Dippings in Corrosive Sublimate Solution (1-1000). With and Without Presprinkling

	PRESPRINKLED			PER CENT		NOT PRESPRINKLED			PER CENT	
No. of dippings	No. of sclerotia	No. dead	No. germinated	Dead	Germinated	No. of sclerotia	No. dead	No. germinated	Dead	Germinated
1	46	44	2	95	5	54	50	4	92	8
2	56	50	6	90	10	56	44	12	79	21
3	59	48	11	80	20	55	43	12	78	22
4	58	50	8	86	14	67	50	19	72	28
5	86	66	20	76	24	70	46	24	65	35
6	68	48	20	70	30	69	47	22	69	31
Check	50	0	50	0	100	50	0	50	0	100

The data submitted in table 1 tend to show that presprinkling the tubers before treatment increases the efficiency of this particular treatment. It also will be noticed that there is a greater uniformity of results in the presprinkled series than in the unsprinkled series.

Differing from the treatments of Vaughan and Brann (21), the authors of this work did not permit the tubers to remain submerged in water previous to treatment. By holding the potatoes under moist conditions for the allotted time, the sclerotia were not merely softened, but they actually germinated. Plate I, figure 3, shows how the sclerotia germinate after the tubers have been held under moist conditions for 48 hours. In this condition, it is apparent that they should be much more susceptible to subsequent treatment than they would be had they been submerged for an equal length of time. When held under moist conditions, all of the sclerotia, from the smallest to the largest, responded quite readily to the extent that all of them presented a white, cottony mycelial growth when tubers were removed. The first reference to this preliminary presprinkle

*This work was done in cooperation with the Department of Horticulture of the Idaho Agricultural Experiment Station.

treatment was made by the authors in abstract form in Phytopathology, September 1922 (17).

Table II

Effect of Various Seed Treatments of Tubers upon Germination of Sclerotia of Rhizoctonia Solani, Kühn. Laboratory Tests 1922

	Treatment	Concentration	Time	Temperature	Per cent dead	Per cent
1	Check (No treatment)					
2	Formalin	50	1 Min.			
3	Formalin	50	2 Min.			
4	Formalin		3 Min.	5		
5	Formalin		4 Min.	5		
6	Formalin		5 Min.			
7	Check (No treatment)					
8	Formalin		1 Min.			
9	Formalin		2 Min.			
10	Formalin		3 Min.			
11	Formalin		4 Min.			
12	Formalin		5 Min.			
13	Check (No treatment)					
14	Formalin presprinkled, covered 24 hrs.		1 Min.	5		
15	Formalin presprinkled, covered 24 hrs.				98.9	
16	Formalin presprinkled, covered 24 hrs.					
17	Formalin presprinkled, covered 24 hrs.	2				
18	Formalin presprinkled, covered 24 hrs.					
1	Check (No treatment)					
2	Formalin presprinkled, covered 24 hrs.			52		
21	Formalin presprinkled, covered 24 hrs.			52		
22	Formalin presprinkled, covered 24 hrs.			52		
23	Formalin presprinkled, covered 24 hrs.			52		
24	Formalin presprinkled, covered 24 hrs.			52		
19	Check (No treatment)					
20	Formalin presprinkled, covered 48 hrs.					
	Formalin presprinkled, covered 48 hrs.					
	Formalin presprinkled, covered 48 hrs.					
	Formalin presprinkled, covered 48 hrs.	96				
	Formalin presprinkled, covered 48 hrs.					
31	Check (No treatment)					
32	Mercuric chloride	1:500				
33	Mercuric chloride	1:1000	1 Hrs.			
34	Mercuric chloride	1:1000	2 Hrs.			
	Mercuric chloride, presprinkled, cov. 24 hrs.	1:1000				
	Mercuric chloride, presprinkled, cov. 24 hrs.	1:1000	1 Hrs.			
	Mercuric chloride, presprinkled, cov. 24 hrs.					
	Check (No treatment)					
	Mercuric chloride presprinkled, cov. 24 hrs.	1:1000				
	Mercuric chloride presprinkled, cov. 24 hrs.	1:1000	1 Hrs.			
	Mercuric chloride presprinkled, cov. 24 hrs.					
	Mercuric chloride presprinkled, cov. 24 hrs. rinsed after treatment		1 Hr.			
	Mercuric chloride presprinkled, cov. 24 hrs. rinsed after treatment	1:1000	1 Hrs.	Cold		
	Mercuric chloride presprinkled, cov. 24 hrs. rinsed after treatment		2 Hrs.	Cold		
	Check (No treatment)					
	Mercuric chloride presprinkled, cov. 48	1:1000	1 Hr.	Cold		
	Mercuric chloride presprinkled, cov. 48	1:1000	1½ Hrs.	Cold		
	Mercuric chloride presprinkled, cov. 48	1:1000	2 Hrs.	Cold		
	Mercuric chloride presprinkled, cov. 48 hrs. rinsed after treatment		1 Hr.	Cold		
	Mercuric chloride presprinkled, cov. 48 hrs. rinsed after treatment		1½ Hrs.	Cold	91.2	8.8
	Mercuric chloride presprinkled, cov. 48 rinsed after treatment		1½	Cold	91.4	8.6

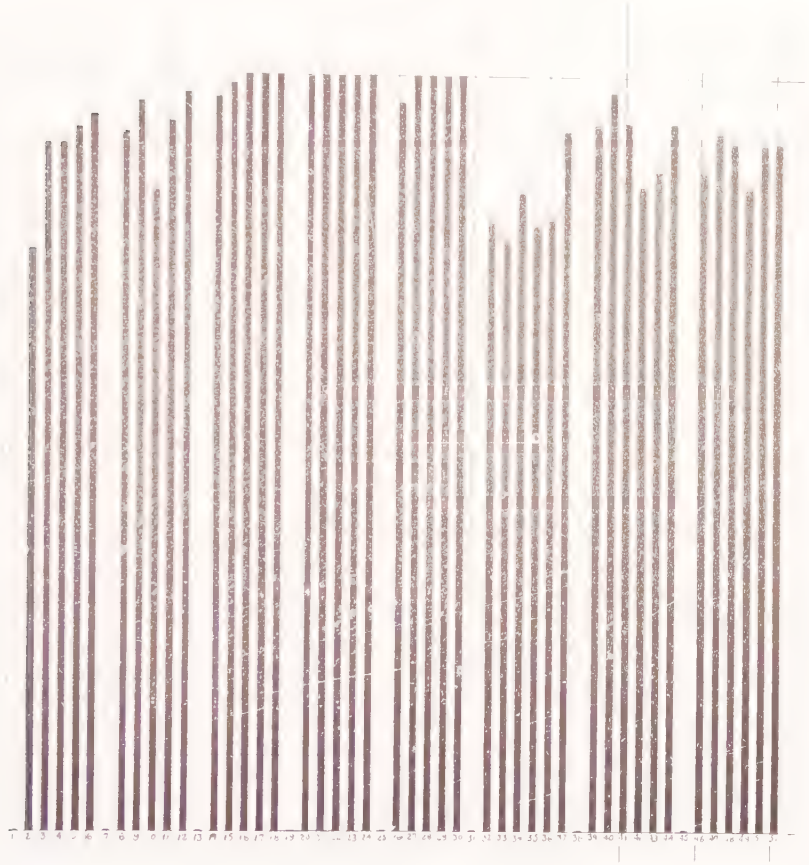
In extensive tests carried on in the laboratory in 1922, the hot formaldehyde series gave much better results. The treatments used and

the results obtained are tabulated in table II. Treatments 1, 7, 13, 19, 25, 31, 38, and 45 are, as indicated, checks with no treatment. One hundred per cent germination of the sclerotia was obtained in every case. Treatments 2 to 6 inclusive are with formalin at 50° C. with 1, 2, 3, 4 and 5 minutes immersion respectively. The percentage of germination ranged from 23.2 at one minute exposure to 5.6 at five minutes exposure. Treatments 8 to 12 inclusive were with the formalin at 55° C. The percentage of germination of the sclerotia ranged from 15.4 at three minutes exposure to 2.5 at five minutes exposure. The discrepancy of treatment No. 10 is unaccounted for. Treatments 14 to 24, excluding treatment No. 19, which is a check, are the same as treatments 2 to 12, excluding No. 7, which is also a check, but with this addition, the tubers were sprinkled with water and covered 24 hours before treatment. Sclerotia treated in this fashion, when immersed in formalin at 50° C. for one minute gave 3 per cent germination; those immersed for two minutes gave 1.1 per cent germination; those exposed for three, four and five minutes were completely killed. Likewise, sclerotia sprinkled with water and covered 24 hours previous to treating with formalin at 55° C. for 1, 2, 3, 4 and 5 minutes gave no germination whatsoever. Another set of tubers was sprinkled with water and covered for 48 hours. They were divided into five groups and immersed in formalin at 50° C. for 1, 2, 3, 4, and 5 minutes respectively. Only in one case was there any germination of the sclerotia, namely, that of the one minute immersion. The percentage of germination in this case was 3.5. A series of treatments with mercuric chloride was used as a comparison with the formalin treatments. Treatments 32, 33 and 34 were with this chemical, immersing the tubers for 1, 1½ and 2 hours respectively. To determine if mercuric chloride produced any residual effect, a second series similar to the above three were rinsed in distilled water after treatment. Each group was rinsed three times. The results show that this had no effect on the germination of the sclerotia and that the residual effect of the mercuric chloride was not removed by rinsing. The washings were not tested for the presence of mercury. Sprinkling with water and covering for 24 and 48 hours before treatment increased the efficiency of the mercuric chloride treatment somewhat, but in no case was the control absolute. The lowest percentage of germination obtained was 2 in the case of the 1½ hour treatment following the sprinkle and the 24 hour covering. Rinsing after these treatments did not increase or decrease the fungicidal value of the mercuric chloride to any marked extent, as far as absolute control was concerned.

Figure 1 shows in graphic form the results obtained in the laboratory in 1922. The numbers at the bottom of the chart correspond to the numbers in table II. The chart should be interpreted in percentage of control.

Figure 1

Results of Laboratory Experiments for Rhizoctonia Control Showing the Percentage of Control for Each Treatment



The type of germination of sclerotia after treatment with mercuric chloride was found to be similar to that described by Melhus and Gilman (14). See plate III, figures 1 and 2. This type of germination further bears out the assumption that there is a residual effect of the mercuric chloride. At this time it might be well to describe the two types of germination of the sclerotia following treatments with mercuric chloride and formalin and to mention the possible effect such germination might have

on control under field conditions. As before stated, in culturing the sclerotia, the side of the sclerotia next to the tuber was always placed uppermost in the dish. When germination took place, following treatment with formalin, the growth was always very spreading, plate III, Figure 3. In two day's time, the growth spread from one-half to three-quarters and sometimes to one inch in diameter around each germinating sclerotia. This was not the case following treatment with corrosive sublimate. In many cases the growth was barely discernable. This always took place in the center of the inverted sclerotia as a small cottony tuft of mycelium, nor would it spread further, not even to the media. It is apparent then that there is some residual effect of the mercuric chloride, or as Melhus and Gilman (16) state, an "antiseptic" action.

Would not this quality shown by mercuric chloride then have a considerably different influence on control under field conditions than is possessed by formalin? If the center of the sclerotium, still adhering to the tuber, was not killed by treatment with mercuric chloride, as is apparently often the case, and if it were impossible for that growth to penetrate the surrounding tissue, the possibility of infecting the growing crop from such a source would be quite negligible when compared to a similar condition following treatment with formalin. In other words, complete killing of the sclerotia by the formalin must take place to insure against infection of the growing crop. This might explain why the use of mercuric chloride has been more satisfactory in the Northwest where, as has been shown above, very large sclerotia are the rule.

Laboratory tests were conducted in 1923 similar to those of 1922. The rinsing after treatment, however, was eliminated and in its place various treatments with hot water were substituted. The mercuric chloride treatments were conducted a little differently in 1923 than in 1922. Instead of immersing from 1 to 2 hours, as was done in 1922, the lengths of exposure in 1923 varied from ½ to 1½ hours. The formalin treatments were quite similar both years.

The response obtained in 1923 was not as complete as it was in 1922. The conditions under which the tests were run were similar as was the personal equation. The difference in response, therefore, may have been due to the organism itself in view of the fact that the sclerotia were obtained from potatoes which were from a different source than those of 1922. Out of twenty various treatments with hot formalin, complete control was secured with but four of them, or 18.2 per cent, while 50 per cent of the formalin trials in 1922 gave absolute control. Complete control was obtained with formalin (1-120) at 50° C. for 2 minutes fol-

lowing a presprinkle and 24 hour covering; with formalin at 55° C. for 3 minutes following the presprinkle and 24 hour covering; with formalin at 50° C. for 3 minutes following a presprinkle and 48 hour covering; and with formalin at 55° C. for 3 minutes following a prespringling and a 48 hour covering.

Neither were the mercuric chloride treatments of 1923 as successful as were those of 1922. From the 1923 results, it is quite apparent that

Table III

Effect of Various Seed Treatments of Tubers upon Germination of Sclerotia of Rhizoctonia Solani, Kuhn. Laboratory Tests 1923

	TREATMENT	Concentration	Time	Temperature	No. dead	No. alive	Per cent dead	Per cent alive
1.	Check (No treatment)				0	98	0	100
2.	Formalin	1-120	1 Min.	50° C.	56	44	56	44
3.	Formalin	1-120	2 Min.	50° C.	62	36	63.3	36.7
4.	Formalin	1-120	3 Min.	50° C.	77	21	78.6	21.4
5.	Formalin	1-120	4 Min.	50° C.	66	11	85.7	14.3
6.	Formalin	1-120	5 Min.	50° C.	88	10	89.8	10.2
7.	Check (No treatment)				0	85	0	100
8.	Formalin	1-120	1 Min.	55° C.	83	17	83.0	17
9.	Formalin	1-120	2 Min.	55° C.	86	13	86.9	13.1
10.	Formalin	1-120	3 Min.	55° C.	91	10	90.1	9.9
11.	Formalin	1-120	4 Min.	55° C.	73	21	77.7	22.3
12.	Formalin	1-120	5 Min.	55° C.	62	31	67	33.0
13.	Check (No treatment)				0	100	0	100
14.	Formalin presprinkled, covered 24 hrs.	1-120	1 Min.	50° C.	43	57	43	57.0
15.	Formalin presprinkled, covered 24 hrs.	1-120	2 Min.	50° C.	73	27	73	27.0
16.	Formalin presprinkled, covered 24 hrs.	1-120	3 Min.	50° C.	89	11	89	11.0
17.	Formalin presprinkled, covered 24 hrs.	1-120	1 Min.	55° C.	95	6	94.1	5.9
18.	Formalin presprinkled, covered 24 hrs.	1-120	2 Min.	55° C.	100	0	100	0.0
19.	Formalin presprinkled, covered 24 hrs.	1-120	3 Min.	55° C.	100	0	100	0.0
20.	Check (No treatment)				0	100	0	100
21.	Formalin presprinkled, covered 48 hrs.	1-120	1 Min.	50° C.	79	21	79	21
22.	Formalin presprinkled, covered 48 hrs.	1-120	2 Min.	50° C.	75	25	75	25
23.	Formalin presprinkled, covered 48 hrs.	1-120	3 Min.	50° C.	100	0	100	0
24.	Formalin presprinkled, covered 48 hrs.	1-120	1 Min.	55° C.	86	14	86	14
25.	Formalin presprinkled, covered 48 hrs.	1-120	2 Min.	55° C.	91	8	91.9	8.1
26.	Formalin presprinkled, covered 48 hrs.	1-120	3 Min.	55° C.	100	0	100	0
27.	Check (No treatment)				0	100	0	100
28.	Mercuric chloride	1-1000	½ Hr.	Cold	36	64	36	64
29.	Mercuric chloride	1-1000	1 Hr.	Cold	62	38	62	38
30.	Mercuric chloride	1-1000	1½ Hrs.	Cold	73	27	73	27
31.	Mercuric chloride presprinkled, covered 24 hrs.	1-1000	½ Hr.	Cold	43	57	43	57
32.	Mercuric chloride presprinkled, covered 24 hrs.	1-1000	1 Hr.	Cold	64	36	64	36
33.	Mercuric chloride presprinkled, covered 24 hrs.	1-1000	1½ Hrs.	Cold	52	48	52	48
34.	Check (No treatment)				0	100	0	100
35.	Mercuric chloride presprinkled, covered 48 hrs.	1-1000	½ Hr.	Cold	33	67	33	67
36.	Mercuric chloride presprinkled, covered 48 hrs.	1-1000	1 Hr.	Cold	70	30	70	30
37.	Mercuric chloride presprinkled, covered 48 hrs.	1-1000	1½ Hrs.	Cold	69	31	69	31
38.	Water							
39.	Water							
40.	Water							
41.	Check							
42.	Water		1 Min.					
43.	Water		2 Min.	55° C.				
44.	Water		3 Min.	55° C.				
45.	Water presprinkled, covered 24 hrs.		1 Min.	50° C.				
46.	Water presprinkled, covered 24 hrs.		2 Min.	50° C.				
47.	Water presprinkled, covered 24 hrs.		3 Min.	50° C.				
48.	Check (No treatment)							
49.	Water presprinkled, covered 24 hrs.		1 Min.	55° C.	32	61	34.4	65.6
50.	Water presprinkled, covered 24 hrs.		2 Min.	55° C.	54	37	59.3	40.7
51.	Water presprinkled, covered 24 hrs.		3 Min.	55° C.	74	26	71.4	28.6

exposures of one-half or of one hour are insufficient for control and, altho the 1½ hour exposure is the standard recommendation, this in two cases did not prove as effective as the one hour exposure. Altho the results of 1923 are not as consistent as those of 1922, still it will be noticed that preprinkling again increased the efficiency of the various treatments with which it was used.

Table III gives a list of treatments used and the results obtained from them in 1923. It is interesting to note upon examining the table that hot water alone had some influence. In one instance, immersing tubers which had previously been sprinkled and covered for 24 hours, in water at 55° C. gave 71.4 per cent control.

Figure II

Results of Laboratory Experiments for Rhizoctonia Control Showing the Percentage of Control for Each Treatment

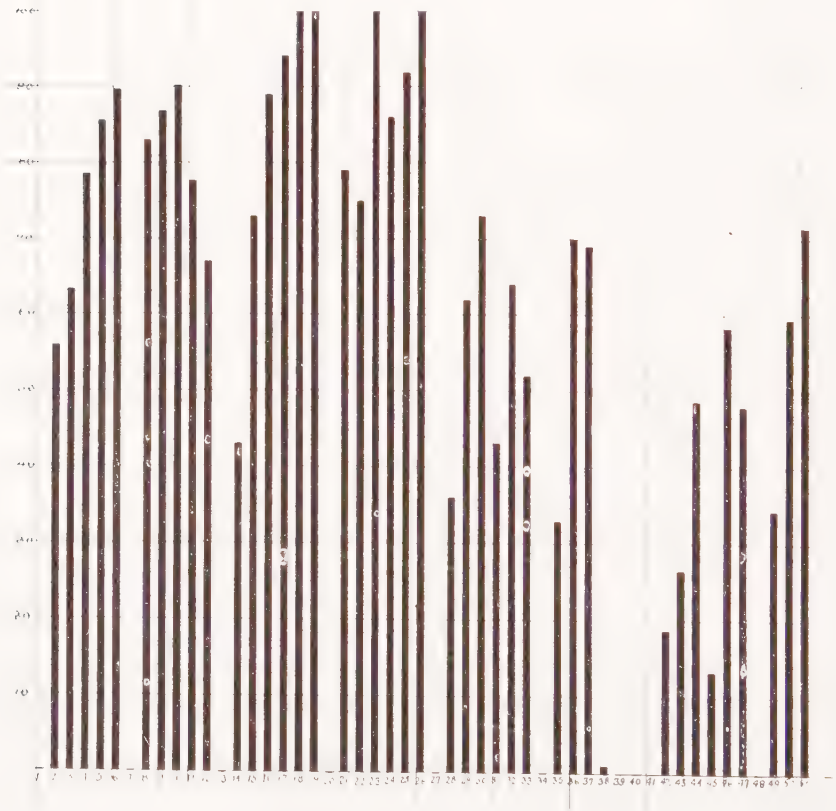


Figure 2 gives in graphic form, the results obtained in the laboratory in 1923. The numbers at the bottom of the chart correspond to the numbers in table III. The chart should be interpreted in percentage of control.

Laboratory Test With Furfural

The junior author made some rather extensive laboratory tests of furfural secured through the courtesy of the Miner Chemical Laboratories of Chicago. Tests were made of cold and hot furfural, varying both the concentration and the time of soaking. These treatments were compared with the cold formaldehyde, the hot formaldehyde and the mercuric chloride methods of treatment. The methods employed in carrying on the treatments and in culturing the sclerotia were the same as those described above. After all hot furfural treatments, the tubers were covered for one hour before the sclerotia were removed for culturing.

Table IV

The Toxic Action of Furfural and Certain Other Chemicals Under Various Conditions on the Sclerotia of Rhizoctonia

	Treatment	Concentration	Time	Temperature	No. dead	No. alive	Per cent dead	Per cent alive
1.	Furfural	1-120	1 Hr.	Cold	.....	.....	0	100
2.	Furfural presprinkled, covered 48 hrs.	1-120	1 Hr.	Cold	.....	.....	0	100
3.	Furfural presprinkled, covered 48 hrs.	1-120	3 Min.	50° C.	53	61	46.5	53.5
4.	Furfural presprinkled, covered 48 hrs.	1-120	5 Min.	50° C.	92	9	91.0	8.9
5.	Furfural presprinkled, covered 48 hrs.	1-120	7 Min.	50° C.	94	11	89.4	10.4
6.	Furfural presprinkled, covered 48 hrs.	1-120	10 Min.	50° C.	93	7	93.0	7.0
7.	Furfural presprinkled, covered 48 hrs.	1-120	3 Min.	55° C.	96	7	93.1	6.9
8.	Furfural presprinkled, covered 48 hrs.	1-120	5 Min.	55° C.	202	14	93.5	6.5
9.	Furfural presprinkled, covered 48 hrs.	1-120	7 Min.	55° C.	204	18	91.8	8.2
10.	Furfural presprinkled, covered 48 hrs.	1-60	1 Hr.,	Cold	.....	.....	0	100
11.	Furfural presprinkled, covered 48 hrs.	1-60	3 Min.	50° C.	91	37	71.1	28.8
12.	Furfural presprinkled, covered 48 hrs.	1-60	5 Min.	50° C.	91	19	82.7	17.3
13.	Furfural presprinkled, covered 48 hrs.	1-60	7 Min.	50° C.	96	8	92.3	7.6
14.	Furfural presprinkled, covered 48 hrs.	1-60	10 Min.	50° C.	.....	.....	100	0
15.	Furfural presprinkled, covered 48 hrs.	1-60	3 Min.	55° C.	195	19	91.0	9.0
16.	Furfural presprinkled, covered 48 hrs.	1-60	5 Min.	55° C.	86	1	98.8	1.2
17.	Furfural presprinkled, covered 48 hrs.	1-40	1 Hr.,	Cold	95	17	84.9	15.1
18.	Formalin	1-120	1 Hr.	Cold	65	33	64.2	33.6
19.	Formalin presprinkled, covered 48 hrs.	1-120	1 Hr.	Cold	75	21	77.6	22.3
20.	Formalin presprinkled, covered 48 hrs.	1-120	3 Min.	50° C.	114	3	97.4	2.5
21.	Formalin presprinkled, covered 48 hrs.	1-120	3 Min.	50° C.	104	1	99.5	5.5
22.	Formalin presprinkled, covered 48 hrs.	1-120	3 Min.	50° C.	99	4	96.1	3.9
23.	Formalin presprinkled, covered 48 hrs.	1-120	3 Min.	55° C.	.....	.....	100	0
24.	Mercuric chloride	1-1000	1 Hr.,	Cold	84	32	72.4	27.5
25.	Mercuric chloride presprinkled, covered 48 hrs.	1-1000	1 Hr.	Cold	73	33	68.8	31.1
26.	Mercuric chloride presprinkled, covered 48 hrs.,	1-1000	1½ Hrs.	Cold	99	2	98.0	2.0
27.	Check (No treatment)							100

In general, furfural was not as efficient as either the standard corrosive sublimate or hot formaldehyde treatment. Table IV gives in tabular form the results obtained with furfural as compared with the other treatments used.

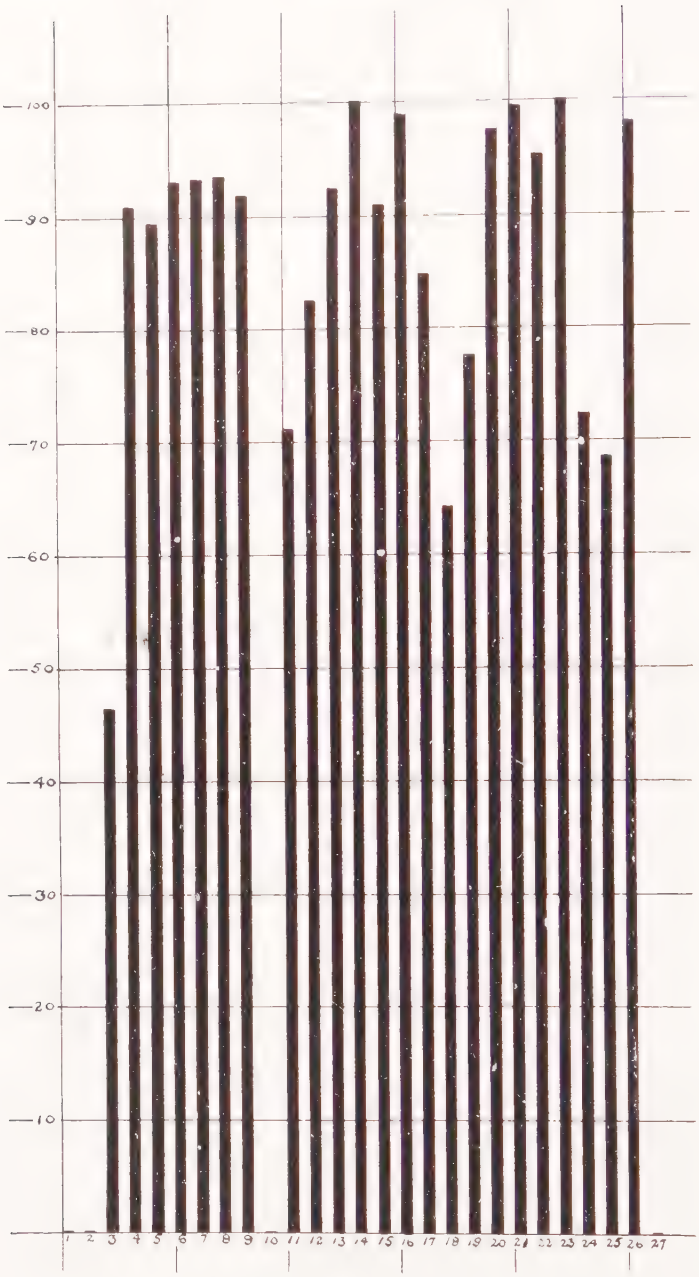


Figure III

Results of Laboratory Experiments for Rhizoctonia Controlwith Furfural Compared with Hot Formaldehyde and Mercuric Chloride Showing the Percentage of Control for Each Treatment

1921

Temperature and time were found to be the most important factors influencing the toxicity of furfural to the sclerotia of rhizoctonia. Cold furfural at the concentrations used is of practically no value. Increased concentration permits a decrease in length of time treated.

Good control was obtained at 55° C. for seven minutes with a concentration of 1-120 and for five minutes with a concentration of 1-60. A concentration of 1-60 for ten minutes at 50° C. gave complete control. These treatments are, however, very severe. Furfural with a concentration of either 1-120 or 1-60 does not compare favorably with the hot formaldehyde and corrosive sublimate treatments when the time is reduced below the above mentioned instances. Several treatments gave fair control, but these are for the most part from 5 per cent to 7 per cent less efficient than hot formaldehyde or corrosive sublimate.

Figure 3 gives in graphic form the results obtained in the laboratory with furfural comparing it with the hot formaldehyde and mercuric chloride methods. For convenience, treatments 20, 21 and 22, the hot formalin checks, were grouped together. The numbers at the bottom of the chart correspond to the numbers in table IV. The chart should be interpreted in percentage of control.

Field Trials

A preliminary field trial with hot formalin was first conducted in 1920, resulting in poor control. This trial was a comparison between the standard mercuric chloride treatment and two hot formalin treatments. Table V shows the amounts of control secured by the methods used. The

Table V

A Comparison of Mercuric Chloride and Hot Formalin in Controlling Rhizoctonia of Potatoes. Field Trial 1920

Treatment	No. of plots	Clean tubers		Rhizoctonia		Per cent clean	Per cent Rhizoctonia
		Marketable	Culls	Marketable	Culls		
1. Check (No treatment)	60	1	0	106	19	.79	99.21
2. Mercuric chloride 1½ hrs.	60	87.5	9.5	37	2	71.32	28.68
3. Formalin 2 min. 118°-112° F.	40	7	1	69	7	55.95	44.05
4. Formalin 5 min. 115°-120° F.	20	11	1	25	1	31.57	68.43

percentages were based upon the number of tubers by weight in the various tests. It can readily be seen that the standard mercuric chloride treatment gave the largest percentage of control. The strength of the mercuric chloride solution was 1-1000, that of the formalin 1-120.

Again in 1921, field trials were conducted primarily to determine the

percentage of loss of strength in a solution of mercuric chloride, 1-1000, when used for treating seed for six successive dippings. In connection with these trials, presprinkling was first used. One set of tubers was presprinkled before treatment, the other set was not.

Unlike the laboratory counts made of these treatments as shown in table I, the results obtained in the field were not as consistent nor as conclusive. In all cases the percentage of rhizoctonia was materially reduced and the percentage of clean product correspondingly increased by treatment. In the case of the first dipping, the dipping which is of most interest, presprinkling materially increased the efficiency of the treatment by reducing the amount of rhizoctonia and increasing the amount of clean product. Table VI gives the results of these trials. The results are given in percentages by weight of marketable and cull tubers, both infected and clean.

Table VI

The Effect of Successive Dipping Upon the Strength of a 1-1000 Solution of Mercuric Chloride, as Interpreted by the Effect Upon the Control of Rhizoctonia, and the Effect of Presprinkling upon Efficiency of Control

Number of dippings	Not presprinkled						Presprinkled					
	Rhizoctonia		Clean				Rhizoctonia		Clean			
	Marketable	Culls	Marketable	Culls	Per cent Rhizoctonia	Per cent Clean	Marketable	Culls	Marketable	Culls	Per cent Rhizoctonia	Per cent Clean
1st dipping	33	18.0	7.9	7.0	78.46	21.54	15	17	25	11	47.05	52.95
2nd dipping	27	8.0	16.0	8.5	58.82	41.18	23	16	13	8	65.00	35.00
3rd dipping	35	14.0	6.5	7.0	78.4	21.60	30	11	11	6	70.69	29.31
4th dipping	22	12.0	18.0	9.0	55.72	44.28	30	8	11	7	67.85	32.15
5th dipping	30	17.0	11.0	10.0	69.11	30.89	21	10	9	7	65.95	34.05
6th dipping	30	16.0	6.0	6.0	79.31	20.69	27.5	17.5	7	10.5	72.00	28.00
Check (No treatment)	79	33.5	7.5	5.5	89.45	10.54	40.0	19.0	3	2	92.18	7.82

Table VII

Comparison of the Efficiency of Mercuric Chloride (1-1000) and Hot Formalin (1-120) in Controlling Rhizoctonia and the Effect of Presprinkling upon that Efficiency

Treatment	Rhizoctonia		Clean		Per cent rhizoctonia	Per cent clean
	Culls	Marketable	Marketable	Culls		
1. Check (No treatment)	235	23	64	7.5	78.3	21.7
2. Formalin 50° C. 3 min. immersion presprinkled covered 48 hours	63	3	322	24	16	84
3. Formalin 50° C. 2 min. immersion presprinkled covered 48 hours	50	7.25	312.25	32	14.3	85.7
4. Mercuric chloride 1½ hours	21	2.75	409.25	36	5.1	94.9
5. Mercuric chloride 1½ hours presprinkled covered 48 hours	67.25	7	300	28	18.5	81.5
6. Formalin 50° C. 2 min. immersion	146	16	217.75	33.75	39.2	60.8
7. Formalin 50° C. 2 min. immersion presprinkled, covered 48 hours	58	2.75	344	33.75	13.9	86.1
8. Check (No treatment)	278.75	23.5	41.5	16.5	77.3	22.7

A more extensive field trial was conducted in 1922. An attempt was made that season to compare the standard mercuric chloride treatment, with and without presprinkling with the hot formaldehyde treatment, with and without presprinkling. Due to lack of adequate seed, the trial was not carried out as extensively as was anticipated. In these trials the standard mercuric chloride treatment proved to be the most efficient means of control. The efficiency of treatment 6, which closely corresponds to the original hot formaldehyde treatment advocated by the Iowa Agricultural Experiment Station, was materially increased by the use of the presprinkle. Any one of the treatments used decreased the percentage of rhizoctonia in the mature crop when compared to the two checks.

No further field trials were conducted until 1924, when a rather extensive number of treatments were tried both at Moscow under non-irrigated conditions and at Lewiston under irrigation. The treatments at Moscow included cold formalin, hot formalin at different temperatures and lengths of immersions, mercuric chloride, hot furfural, copper carbonate dust and organic mercury compounds, both dry and in solutions. There were 28 treatments in all, including three checks. Enough seed was used to plant three replicates of each treatment.

The results obtained at Moscow, shown by table VIII, part 2, again show that presprinkling the potatoes, previous to treating, increased the efficiency of the treatments in nine cases out of twelve. The three cases in which presprinkling did not increase the efficiency of the treatment used are as follows: Treatment 9—formalin at 55° C., 2 minutes immersion; treatment 12—furfural at 50° C., 10 minutes immersion, and treatment 20—Du Pont Dust No. 12., .160 per cent solution at 1½ hour immersion. From the data submitted, it is quite evident that the reasons why presprinkling in the above three cases were not effective in increasing control were due to factors such as soil moisture, amount of soil infection, etc., factors which are not controllable. This is quite evident when the results of treatments 1 and 16 are examined. It will be noticed that the first replication in each case shows considerable freedom from scurf, while the other two replications were heavily infected. In both cases, the first replications were at the edge of the main plot close to sod. It was noticed that the moisture content of the soil there was much less that it was where the other replications were planted. Such factors therefore, would necessarily affect other treatments also which might account for such inconsistencies as is shown by the above three treatments.

Table VIII—Part I

Tests of Various Methods of Seed Treatment for the Control of Rhizoctonia of Potatoes. Moscow, 1924

	Marketable				Culls			
	Clean		Diseased		Clean		Diseased	
	Weight	Number	Weight	Number	Weight	Number	Weight	Number
1. Check	13	80	8	46	10.5	139	2	87
	2.5	11	52	186	2	19	17.5	223
	10	50	20	100	3	30	7.0	100
2. Cold formalin (1-120), 1½ hr. soak	8.5	52	9	72	3	51	6	85
	6.5	26	59.5	225	2	25	15.5	187
	5.5	27	29	152	2.5	45	9.5	148
3. Cold formalin (1-120) 1½ soak, presprinkled	10.5	56	6.5	33	6.5	91	3	42
	16.0	70	44.5	173	3.0	35	9.0	119
	10.5	43	25	103	7.5	95	16.5	196
4. Formalin (1-120) 50° C. 2 min. cover, 1 hr.	14	84	6.5	37	5.5	89	4.5	61
	42	158	17.5	70	14	152	6	71
	11	58	32.5	150	10	160	3	65
5. Formalin (1-120) 50° C. 2 min., cover 1 hr., presprinkled	23.5	146	3	22	7	100	1.5	22
	41.5	170	16	79	6.5	95	4.0	61
	23.0	115	12	60	8	110	4.0	60
6. Formalin (1-120) 50° C. 4 min., cover 1 hr.	17.5	88	4.0	22	10.5	135	2.0	27
	52.5	238	7.5	31	8.0	90	1.0	13
	28.5	126	18.5	84	20.5	208	7.0	89
7. Formalin (1-120) 50° C. 4 min., cover 1 hr., presprinkled	18.5	105	6.0	32	7.5	94	1.5	23
	30.5	130	6.0	35	29.5	210	1.5	18
	35.0	150	6.0	35	14.0	180	5.0	66
8. Formalin (1-120) 55° C. 2 min., cover 1 hr.	21	116	7.5	37	11.0	145	4.0	49
	44.5	223	5.0	25	4.5	62	1.0	10
	28.5	152	18.5	100	8.0	90	5.0	75
9. Formalin (1-120) 55° C. 2 min., cover 1 hr., presprinkled	25.5	132	6.0	33	12.0	155	3.5	47
	22.5	99	16.0	70	2.0	25	3.5	45
	28.0	146	3.0	15	11.5	145	2.0	29
10. Formalin (1-120) 55° C. 4 min., cover 1 hr.	21.0	104	15.0	75	7.0	91	6.5	32
	38.0	157	11.0	50	11.0	124	3.5	40
	20.5	100	6.0	27	22.5	221	4.0	54
11. Formalin (1-120) 55° C., 4 min., cover 1 hr. presprinkled	31.5	152	5.5	26	12	158	2.5	30
	43.5	202	7.0	28	6	64	2.0	20
	25.0	117	1.0	6	14.5	178	1.5	22
12. Furfural (1-60) 50° C., 10 min.	30.0	139	5.0	24	11.0	56	4.5	61
	31.5	139	6.0	24	10.0	122	4.0	53
	27.5	144	5.0	29	14.0	175	2.0	40

Table VIII—Part I (Continued)

	Marketable				Culls			
	Clean		Diseased		Clean		Diseased	
	Weight	Number	Weight	Number	Weight	Number	Weight	Number
13. Furfural (1-60) 50° C., 10 min., presprinkled	26.5	135	4.5	23	9.5	126	1.5	[illegible]
	32.5	154	8.0	41	9.5	121	1.0	[illegible]
	30.0	123	12.5	59	14.0	138	5.5	[illegible]
14. Mercuric chloride (1-1000) 1¼ hr.	29.0	135	14.0	56	7.5	107	2.5	[illegible]
	29.5	137	15.0	63	8.0	102	2.5	[illegible]
	35.0	151	4.0	16	15.0	147	3.0	[illegible]
15. Mercuric chloride (1-1000) 1½ hr. presprinkled	32.5	159	3.0	43	10.0	118	.5	[illegible]
	31.5	183	6.0	25	7.5	88	1.0	[illegible]
	44.5	207	6.0	32	10.0	126	.5	[illegible]
16. Check	30.0	152	8.0	38	8.0	102	5.0	[illegible]
	.5	3	52.5	215	1.0	9	10.0	137
	1.5	8	41.0	200	1.0	10	11.0	160
17. Du Pont Dust No. 15, 3 oz. per bu.	50.0	229	14.5	62	8.5	93	2.0	[illegible]
	5.0	26	31.5	142	2.0	43	10.0	150
	40.0	200	9.0	45	7.0	90	2.0	[illegible]
18. Du Pont Dust No. 15, 3 oz. per bu., presprinkled	48.5	200	5.0	24	6.0	81	1.5	[illegible]
	40.0	190	8.0	36	8.0	130	2.0	[illegible]
	39.5	180	.5	2	12.0	150	0.	[illegible]
19. Du Pont No.12, .1666% sol. 1½ hr.	18.5	77	33.0	138	5.0	59	6.5	[illegible]
	29.5	137	11.0	45	8.0	100	3.0	[illegible]
	9.0	48	35.0	172	2.0	33	6.0	[illegible]
20. Du Pont No. 12, .1666% sol. 1½ hr presprinkled	26.5	116	28.0	117	8.0	98	6.5	[illegible]
	9.0	41	33.5	152	3.0	52	8.5	117
	11.0	52	33.5	154	3.5	42	7.0	105
21. Semesan Dust, 3 oz. per bu.	42.5	205	9.0	37	7.5	88	2.5	[illegible]
	17.5	83	26.0	125	5.0	60	4.0	[illegible]
	45.0	222	10.0	49	7.5	95	1.5	[illegible]
	4.5	190	8	36	7	93	2.5	[illegible]
22. Semesan Dust, 3 oz. per bu. presprinkled	38.0	170	14	56	8	107	3.0	[illegible]
		156	5	24	10	120	1.0	[illegible]
	26.5	127	25	115	5.5	63	6.0	[illegible]
23. Semesan .125% sol. 1½ hr.	30.5	168	12.5	55	9.0	92	2.5	19
	15.0	72	24.0	108	7.0	89	6.0	72
24. Semesan .125% sol. 1½ hr. presprinkled	13.5	66	3.0	12	7.0	76	3.0	[illegible]
	25.5	116	21.5	97	7.0	81	4.5	[illegible]
	18.5	97	23.0	110	7.0	110	3.5	[illegible]
25. Copper carbonate dust, 3 oz. per bu.	10.5	55	33.5	158	6.5	79	16.5	205
	23.5	108	29.0	112	3.5	43	5.0	[illegible]
	8.0	45	26.0	145	2.5	35	6.0	[illegible]
26. Copper carbonate dust, 3 oz. per bu. presprinkled	10.0	49	12.5	62	7.0	95	6.0	[illegible]
	11.5	66	19.0	96	3.5	51	4.5	[illegible]
	10.0	50	22.0	107	3.0	48	5.5	[illegible]
27. Clean seed—Mercuric chloride (1-1000) 1½ hr. presprinkled	28.0	133	5.0	28	9.5	136	1.5	[illegible]
	13.0	65	18.0	92	4.5	66	5.0	[illegible]
	40.0	166	3.0	21	12.0	58	.5	[illegible]
28. Check—clean seed	12.0	114	15.0	85	17.0	206	2.5	[illegible]
	34.5	169	4.0	24	13.5	167	2.0	[illegible]
	18.0	80	19.0	90	7.5	90	6.0	[illegible]

Table VIII—Part II

Tests of Various Methods of Seed Treatment for the Control of Rhizoctonia of Potatoes.
Moscow 1924

Treatment Number	Plot	Total per cent clean by weight	Total per cent clean by number	MARKETABLE								CULLS							
				Clean				Diseased				Clean				Diseased			
				Wt.	Per cent	No.	Per cent	Wt.	Per cent	No.	Per cent	Wt.	Per cent	No.	Per cent	Wt.	Per cent	No.	Per cent
1	1	70.1	62.2	13	38.[illegible]	80	22.7	8	23.8	46	13.0	10.5	31.3	139	39.5	2	5.9	87	24.7
	2	6.1	6.8	2.5	3.[illegible]	11	2.5	52	70.3	186	42.4	2.0	2.7	19	4.3	7.5	23.6	223	50.8
	3	32.5	28.6	10.0	25.[illegible]	50	17.9	20	50.0	100	35.7	3.0	7.5	30	10.7	7.0	17.5	100	35.7
	Ave	36.2	32.5	8.5	22.[illegible]	47	14.3	26.6	48.0	110.6	30.4	5.1	13.8	62.6	18.2	8.8	15.7	136.6	37.1
2	1	43.3	39.6	8.5	32.[illegible]	52	20.0	9	33.9	72.0	27.7	3.0	11.3	51.0	19.6	6.0	22.6	85.0	32.6
	2	10.2	11.0	6.5	7.[illegible]	26	5.6	59.5	71.2	225.0	48.6	2.0	2.4	25.0	5.4	15.5	18.6	187.0	40.3
	3	18.2	19.4	5.5	11.[illegible]	27	7.3	29.0	62.4	152.0	40.8	2.[illegible]	5.4	45.0	12.1	10.3	20.6	140.0	37.5
	Ave	23.6	23.3	6.8	17.[illegible]	35	10.9	32.5	55.8	149.0	39.0	2.[illegible]	6.4	40.3	12.4	[illegible]	[illegible]	[illegible]	[illegible]
3	1	64.1	66.1	16.5	39.[illegible]	56	25.2	6.5	24.5	33.0	14.9	6.[illegible]	24.5	91.0	40.9	3.0	11.3	42.0	18.9
	2	26.[illegible]	26.4	16.0	22.[illegible]	70	17.6	44.5	61.4	173.0	43.6	3.[illegible]	4.1	35.0	8.8	9.0	12.4	119.0	30.0
	3	30.[illegible]	31.5	10.5	17.[illegible]	43	9.8	25.0	42.0	103.0	23.6	7.[illegible]	12.6	95.0	21.7	16.5	27.7	196.0	44.8
	Ave	40.[illegible]	41.3	12.3	26.[illegible]	56.3	17.5	25.3	42.6	103.0	27.4	5.[illegible]	13.7	73.7	23.8	9.5	17.1	119.0	31.2
4	1	63.[illegible]	63.8	14.0	45.[illegible]	84.0	31.0	6.5	21.3	37.0	13.6	5.[illegible]	18.0	89.0	32.8	4.5	14.7	61.0	22.[illegible]
	2	70.[illegible]	68.7	42.0	5.[illegible]	158.0	35.0	17.5	22.0	70.0	15.5	14.[illegible]	17.7	152.0	33.7	6.0	7.5	71.0	15.[illegible]
	3	37.[illegible]	50.3	13.0	19.[illegible]	58.0	13.4	32.5	57.5	150.0	34.6	10.[illegible]	17.7	160.0	36.9	3.0	5.4	65.0	15.[illegible]
	Ave	57.[illegible]	60.9	22.3	36.[illegible]	100.0	26.5	18.8	33.6	85.7	21.2	9.[illegible]	17.8	137.0	34.4	4.5	9.2	65.6	17.[illegible]
5	1	87.1	84.5	23.5	62.[illegible]	146.0	50.3	3.0	8.5	22.0	7.6	7.[illegible]	20.0	100.0	34.2	1.5	4.2	22.0	7.6
	2	70.[illegible]	65.3	41.5	6.[illegible]	170.0	41.9	16.0	23.2	79.0	19.5	6.[illegible]	9.5	95.0	23.4	4.0	5.8	61.0	15.1
	3	65.9	65.3	23.0	4.[illegible]	115.0	33.3	12.0	25.5	60.0	17.4	8.[illegible]	17.0	110.0	32.0	4.0	8.5	60.0	17.4
	Ave	74.[illegible]	71.7	29.3	56.[illegible]	143.7	41.8	10.3	19.1	53.7	14.8	7.[illegible]	15.5	101.7	29.9	3.2	6.2	47.7	13.4
6	1	82.[illegible]	82.0	17.5	51.[illegible]	88.0	32.4	4.0	11.8	22.0	8.1	10.[illegible]	30.8	135.0	49.6	2.0	5.9	27.0	9.[illegible]
	2	87.[illegible]	88.1	52.5	7.[illegible]	238.0	63.9	7.5	10.8	31.0	8.3	8.[illegible]	11.6	90.0	24.2	1.0	1.5	13.0	3.[illegible]
	3	65.[illegible]	65.9	28.5	3.[illegible]	126.0	24.9	18.5	24.8	84.0	16.7	20.[illegible]	27.5	208.0	41.0	7.0	9.2	89.0	17.[illegible]
	Ave	78	78.7	32.9	5.[illegible]	150.7	40.4	10.0	15.8	45.7	11.0	13.0	23.3	144.3	38.3	3.3	5.5	43.0	10

Table VIII—Part II (Continued)

Treatment Number	Plot	Total per plot (lbs. weight)	Total per cent clean by number	MARKETABLE								CULLS							
				Clean				Diseased				Clean				Diseased			
				No.	Per cent	No.	Per cent	Wt.	Per cent	No.	Per cent	Wt.	No.	Per cent	Wt.	Per cent	No.	Per cent	
	1		78.3	8.	55.	105.0	41.3	6.0	17.6	32.0	1	7.	1	91	37.0	1.5	4.5	23.	9.1
	2		86.5	9.	45.	130.0	33.1	6.0	8.9	35.0		2.	13.8	210	53.1	1.5	2.2	18.	4.6
7	3		76.5	5.	58.	150.	34.8	6.0	10.0	35.0		11.	33.3	180.	41.8	5.0	8.3	66.	15.3
	Ave.		80.5	8.	52.	128.	36.4	6.0	12.2	34.0		17.	29.8	161.	44.1	2.7	5.0	35.	9.7
	1		75.2	1.	48.3	116.0	33.4	7.5	17.2	37.0	1.7	11.	35.3	145.0	41.8	4.0	9.2	49.0	14.1
	2		89.1	4.	80.0	223.0	62.7	5.0	9.1	25.0	.8	4.	8.2	62.0	19.4	1.0	1.8	10.0	3.1
8	3		58.0	8.	47.4	152.0	30.4	18.5	30.8	100.0	2.0	8.	3.3	90.0	21.6	5.0	8.3	75.0	18.0
	Ave.		74.1	1.	58.9	163.0	40.5	10.3	19.0	54.0	1.2	7.	5.6	99.0	27.6	3.3	6.3	44.7	11.7
	1		78.1	5.	54.2	132	35.9	6.0	12.8	33.0	.9	12	55.6	155	42.2	3.5	7.5	47	10
	2		51.9	2.	51.	99	41.4	16.0	36.4	70.0	2.2	2	4.3	25	10.5	3.5	8.0	45	18.4
9	3		85.9	8.	62.9	146	45.6	3.0	6.7	15.0	.5	11.	35.8	115	42.3	2.0	4.5	29	8.6
	Ave.		72.0	5.	56.1	125.7	40.3	6.3	18.6	36.0	1.2	8.	8.6	108.3	31.6	3.0	6.6	40.	12.3
	1		64.5	1.	42.4	104.0	34.4	15.0	30.3	75.0	2.8	7.	4.2	91.0	30.1	6.5	13.1	32.0	10.6
	2		77.5	8.	59.3	157.0	44.4	11.0	17.3	50.0	1.2	11.	7.5	124	33.1	3.5	5.5	40	10.8
10	3		79.7	0	38.5	100.0	25.8	6.0	11.3	27.0	.7	22.	23.5	221	54.9	4.0	7.6	54	13.4
	Ave.		73.9	6.	46.9	123.3	34.5	10.6	19.6	50.7	1.9	13.	34.7	145.3	39.3	4.7	8.7	42	11.6
	1		84.7	1	61.1	152.0	41.5	5.5	10.6	26.0	.1	12.	33.2	158.0	43.2	2.5	4.8	30	8.2
	2		84.6	3	74.3	202.0	64.3	7.0	11.9	28.0	.9	6.	10.2	64.0	20.3	2.0	3.4	20	6.3
11	3		91.3	5	59.5	117.0	30.2	1.0	2.4	6.0	.8	14.	4.5	178	55.1	1.5	3.6	22	6.8
	Ave.		86.8	0	64.9	157.0	45.3	4.8	8.3	16.7	.9	10.	22.6	166.7	39.5	2.0	3.9	24	7.1
	1		69.7	30	59.4	139.0	40.7	5.0	9.9	24.0	.7	11.	31.2	56.0	29.0	4.5	8.9	61	21.7
	2		77.1	31	61.1	139.0	42.1	6.0	11.6	24.0	.1	10.	9.6	122.0	36.0	4.0	7.7	53	15.6
12	3		82.2	27	56.7	144.0	37.1	5.0	10.3	29.0	.5	14.	38.9	175	45.1	2.0	4.1	40	10.3
	Ave.		76.4	29	59.1	140.7	42.6	5.3	7.1	25.7	.8	11.	33.2	117.7	33.7	3.5	6.9	51.3	15.9
	1		86.4	26	63.	135.0	44.	4.5	10.7	23.0	.6	9.	32.6	126.0	41.7	1.5	3.5	18	5.9
	2		81.4	32	63.7	154.0	4	8.0	15.6	41.0	1.1	9.	8.6	121.0	35.8	1.0	1.9	22	6.5
13	3		67.1	30	48.3	123.0	3	12.5	20.2	59.0	1.2	14.	32.	138	35.5	5.5	8.9	59	17.7
	Ave.		78.3	29	58	137.3	4	8.3	15.5	41.0	1.6	11.	31.	128.3	37.7	2.7	.4	36.3	10.0

Table VIII—Part II (Continued)

Treatment Number	Plot	Total per cent clean by weight	Total per cent clean by number	MARKETABLE								CULLS							
				Clean				Diseased				Clean				Diseased			
				Wt.	Per cent	No.	Per cent	Wt.	Per cent	No.	Per cent	Wt.	Per cent	No.	Per cent	Wt.	Per cent	No.	Per cent
14	1	68.8	72.1	29.0	54.7	135.0	40.2	14.0	24.4	56.0	16.7	7.5	14.1	107	31.9	2.5	4.7	37	11.0
	2	68.2	70.6	29.5	53.6	137.0	40.5	15.0	27.2	63.0	18.6	8.0	14.6	102	30.1	2.5	4.7	36	10.6
	3	87.7	86.1	35.0	61.4	151.0	43.6	4.0	7.0	16.0	4.6	15.0	26.3	147	42.5	3.0	5.2	32	9.3
	Ave.	74.9	76.3	31.2	56.6	141.0	41.4	11.0	19.5	45.0	13.3	6.8	18.3	118.7	34.8	2.7	4.9	35	10.3
15	1	92.4	83.9	32.5	70.7	159.0	48.1	3.0	6.5	43.0	13.0	10.0	21.7	118.0	35.8	0.5	1.1	10	3.0
	2	84.8	90.0	31.5	68.5	183.0	60.8	6.0	13.0	25.0	8.3	7.5	16.3	88.0	29.2	1.0	2.2	5	1.7
	3	89.4	90.2	44.5	73.0	207.0	56.1	6.0	9.8	32.0	8.7	10.0	16.4	126.0	34.1	0.5	0.8	4	1.1
	Ave.	88.8	88.0	36.2	70.8	183.0	55.0	5.0	9.8	33.4	10.0	9.2	18.1	110.6	33.0	0.7	1.4	6.3	1.9
16	1	74.5	76.0	30.0	58.8	152.0	45.5	8.0	15.7	38.0	11.4	8.0	15.7	102.0	30.5	5.0	9.8	42	12.6
	2	2.4	3.3	0.5	0.8	3.0	0.8	52.5	82.3	215.0	59.1	1	1.6	9.0	2.5	10.0	15.6	127	37.6
	3	4.6	4.7	1.5	2.8	8.0	2.1	41.0	75.2	200.0	52.9	1	1.8	10.0	2.6	11.0	20.2	160	42.3
	Ave.	27.2	28.0	10.7	20.8	54.3	16.1	33.8	57.7	151.0	41.1	3.3	6.4	40.3	11.9	8.7	15.2	113	30.8
17	1	78.0	79.4	50.0	66.7	229.0	56.5	14.5	19.3	63.0	15.3	8.5	11.3	93.0	22.9	2.0	2.7	21	5.2
	2	14.4	19.1	5.0	10.3	26.0	7.2	31.5	64.9	142.0	39.3	2.0	4.1	43.0	11.9	10.0	20.6	150	41.5
	3	81.0	81.0	40.0	68.9	200.0	55.9	9.0	15.5	45.0	12.6	7.0	12.1	90.0	25.1	2.0	3.4	23	6.4
	Ave.	57.8	59.8	31.7	48.6	151.7	39.9	18.3	33.2	83.0	22.4	5.9	9.2	75.3	19.9	4.7	8.9	64.7	17.7
18	1	89.3	86.1	48.5	79.5	200	61.3	5	8.2	24	7.3	6.0	9.8	81	24.8	1.5	2.4	21	6.4
	2	82.6	85.5	40.0	68.9	190	50.8	8	13.7	36	9.6	8.0	13.7	130	34.7	2.0	3.4	18	4.8
	3	99.0	99.4	39.5	75.9	180	54.2	0.5	0.9	2	0.6	12.0	23.1	150	45.2	0	0	0	0
	Ave.	90.3	90.3	42.7	74.8	190	55.2	4.5	7.6	20.7	6.0	8.7	15.5	120.3	34.9	1.2	1.9	13	3.7
19	1	37.2	39.4	18.5	29.3	77	22.3	33.0	52.3	138.0	40.0	5.0	7.9	59.0	17.1	6.5	10.3	71	20.5
	2	69.4	75.6	29.5	54.6	137	43.7	11.0	20.3	45.0	14.4	8.0	14.8	100.0	31.9	3.0	5.5	31	9.9
	3	21.1	24.0	9.0	17.3	48	14.2	35.0	67.3	172.0	50.8	2.0	3.8	33.0	9.8	6.0	11.5	85	25.1
	Ave.	42.5	46.3	19.0	33.7	87.3	26.7	26.3	46.6	118.3	35.1	5.0	8.8	64.0	19.9	5.2	9.1	62.3	18.5
20	1	50.0	51.2	26.5	38.4	116.0	27.8	28.0	40.6	117.0	27.9	8.0	11.6	98	23.4	6.5	9.4	87	20.8
	2	22.3	25.5	9.0	16.7	41.0	11.1	33.5	62.0	152.0	41.9	3.0	5.6	52	14.4	8.5	15.7	117	32.3
	3	26.4	26.6	11.0	20.0	52.0	14.7	35.5	60.9	154.0	43.6	3.5	6.4	42	11.9	7.0	12.7	105	29.7
	Ave.	32.9	34.4	15.5	25.0	69.7	17.9	31.6	54.5	141.0	37.8	4.8	7.9	64	16.6	7.3	12.6	103	27.6

Table VIII—Part II (Continued)

Treatment Number	Plot	Total per cent clean by weight	Total per cent clean by number	MARKETABLE								CULLS							
				Clean				Diseased				Clean				Diseased			
				Wt.	Per cent	No.	Per cent	Wt.	Per cent	No.	Per cent	Wt.	Per cent	No.	Per cent	Wt.	Per cent	No.	Per cent
1	1	81.3	81.3	2.5	69.0	205	56.9	9.0	14.6	37	10.	7.5	12.2	88	24.4	2.5	4.1	30	8.
	2	42.8	45.1	7.5	33.	83	26.2	26.0	49.5	125	39.	5.0	9.5	60	18.9	4.0	7.6	50	15.
	3	82.0	84.2	5.0	70.	222	56.9	10.0	15.6	49	12.	7.5	11.7	95	24.3	1.5	2.4	24	6.
	Ave.	68.7	69.2	5.0	57.7	170	46.7	15.0	26.6	70.3	20.	6.7	11.1	81	22.5	2.7	4.4	34.7	10.
2	1	83.0	81.5	4.5	71.	190	54.7	8.0	12.9	36.0	10.	7.0	11.3	93	26.8	2.5	4.0	28	8.
	2	73.0	74.6	8.0	60.	170	45.8	14.0	22.2	56.0	15.	8.0	12.7	107	28.8	3.0	4.8	38	10.
	3	88.3	86.5	5.5	68.	156	48.9	5.0	9.7	24.0	7.	10.0	19.4	120	37.6	1.0	1.9	19	5.
	Ave.	81.4	80.9	9.3	66.	172	49.8	9.0	14.9	38.7	11.	8.3	14.5	106.7	31.1	2.2	3.6	28.3	8.
23	1	50.8	48.2	6.5	42.	127	32.9	25.0	39.7	115.0	29.	5.5	8.7	63	16.3	6.0	9.5	81	20.
	2	76.4	77.8	9.5	62.	168	50.3	12.5	19.6	55.0	16.	9.0	14.2	92	27.5	2.5	3.9	19	5.
	3	42.3	47.2	5.0	28.	72	21.1	24.0	46.1	108	31.	7.0	13.5	89	26.1	6.0	11.5	72	21.
	Ave.	56.5	58.0	7.0	44.	122.3	34.8	20.5	35.1	92.7	25.	7.2	12.	81.3	22.3	4.8	8.3	57.3	15.
24	1	77.3	73.6	3.5	50.	66	33.3	3.0	11.3	12	6.	7.0	26.4	76	38.3	3.0	11.3	44.0	22.
	2	55.4	55.0	5.5	43.	116	32.4	21.5	36.7	97	27.	7.0	11.9	81	22.6	4.5	7.7	64.0	17.
	3	49.0	54.8	8.5	35.	97	25.7	23.0	44.2	110	29.	7.0	13.5	110	29.1	3.5	6.7	61.0	16.
	Ave.	60.6	60.4	39.2	43.	93	30.4	15.8	30.7	73	20.	7.0	17.3	89	30.0	3.7	8.5	56.3	18.
25	1	25.4	27.0	10.5	15.	55	11.1	33.5	50.0	158	31.	6.5	9.	79		6.5	24.6	205	41.
	2	44.2	47.3	23.5	38.	108	33.8	29.0	47.5	112	35.	3.5	5.	43		5.0	38.2	56	17.
	3	24.7	25.0	8.0	18.	45	14.1	26.0	61.1	145	45.	2.5	5.	35		6.0	14.1	94	29.
	Ave.	31.4	33.1	14.0	24.	69.3	19.3	29.5	52.8	138.3	37.	4.2	7.	51.7		9.2	15.6	118.3	29.
26	1	47.9	48.3	0.0	28.	49	16.4	12.5	35.2	62	20.	7.0	19.7	95		6.0	16.9	92	30.
	2	38.9	41.0	1.5	29.	66	24.2	19.0	49.3	96	35.	3.5	9.	51		4.5	11.7	59	21.
	3	32.1	33.2	00.0	24.	50	17.9	22.0	54.3	107	38.	3.0	7.	48		5.5	13.6	73	26.
	Ave.	39.9	41.1	10.5	28.	55	19.5	17.8	46.3	88.3	31.	4.5	12.	64.7		5.3	14.1	74.7	26.
27	1	85.2	85.8	28.0	63.	133	41.4	5.0	11.4	28.0	8.	9.5	21.	136		1.5	3.4	24	7.
	2	43.2	44.2	13.0	32.	65	21.9	18.0	44.4	92.0	31.	4.5	11.	66		5.0	12.3	73	24.
	3	93.7	94.7	40.0	72.	166	67.2	3.0	5.4	21.0	8.	12.0	21.	58		0.5	0.9	2	0.
	Ave.	74.0	74.9	27.0	55.	121.3	43.5	8.7	20.4	47.0	16.	8.7	18.	86.7		2.3	5.5	33	11.
28	1	62.4	73.	12.	25.	114	26.0	15	32.3	85	19.	17	36.	206		2.5	5.4	33	7.
	2	88.9	89.1	34.5	63.	169	44.8	4	7.4	24	6.	13.5	25.	167		2.0	3.7	17	4.
	3	50.5	51.8	18.0	35.	80	23.9	19	37.6	90	26.	7.5	14.	90		6.0	11.9	75	22.
	Ave.	67.3	70.9	21.8	41.	121	31.5	12.7	25.8	66.3	17.	12.7	25.	154.3		3.5	7.	41.7	11.

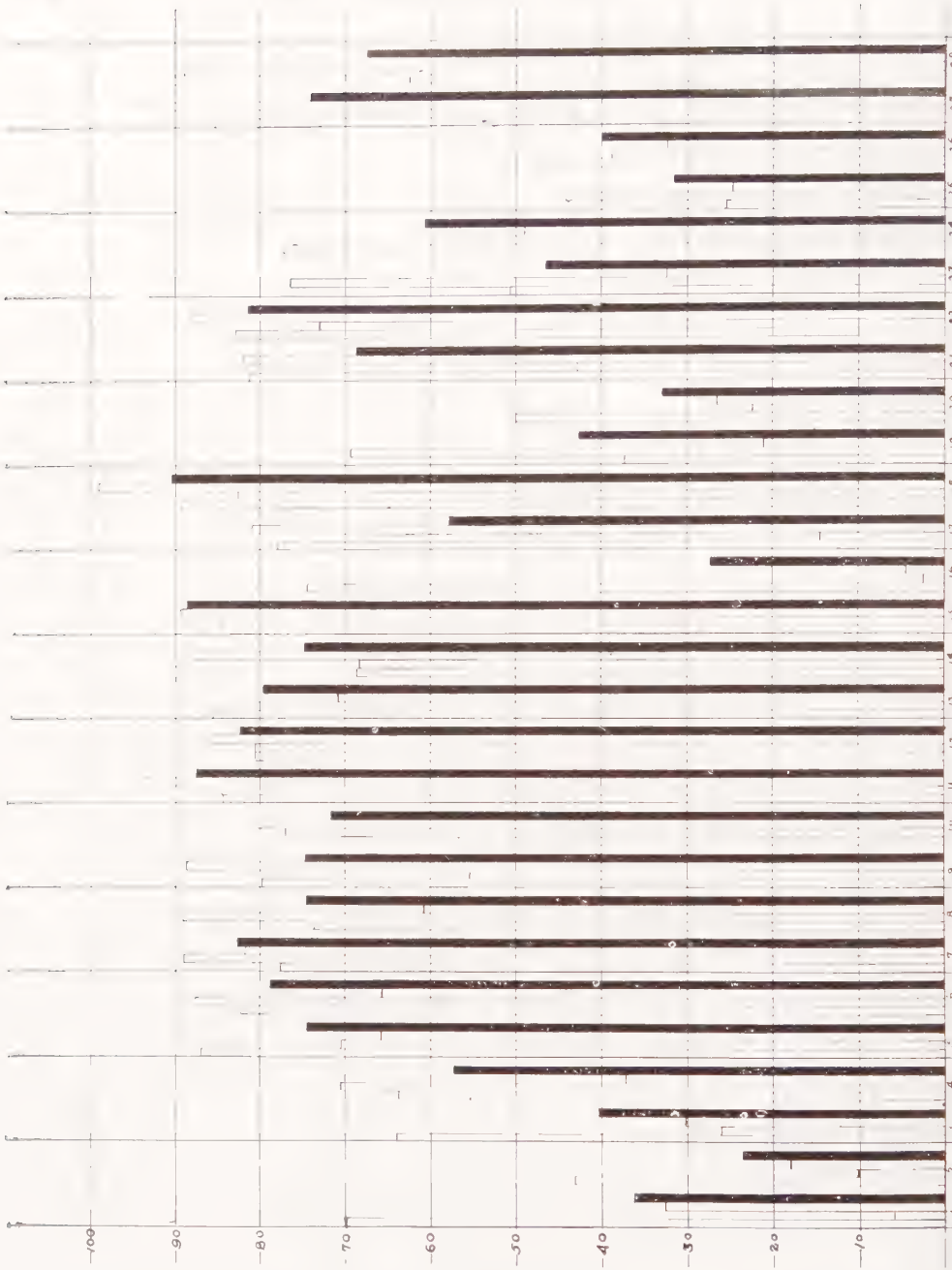


Figure IV

Results of Field Experiments for Rhizoctonia Control giving Percentage of Clean Tubers by Weight as Shown by three Replications and the Average for each Treatment

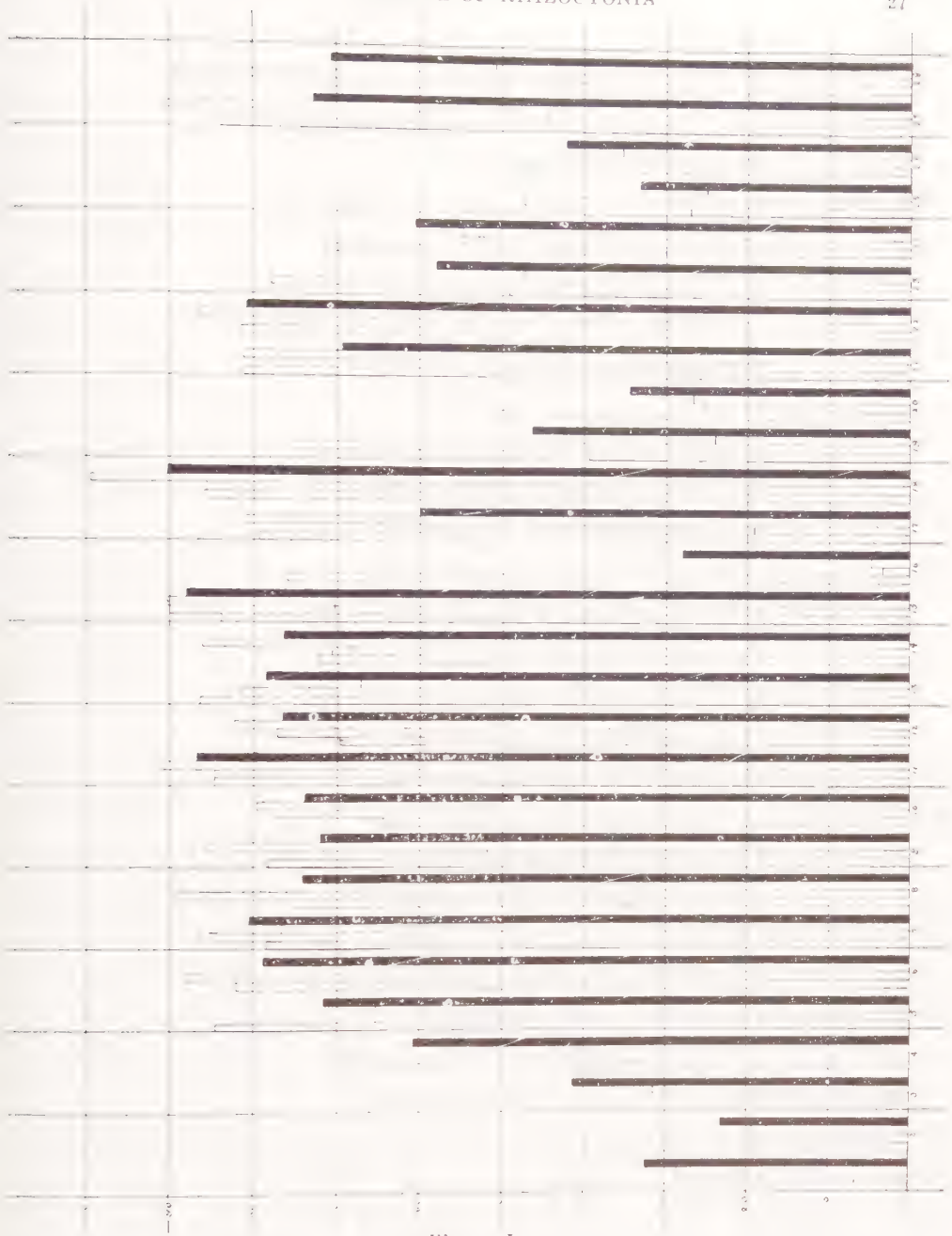


Figure V

Results of Field Experiments for Rhizoctonia Control giving Percentage of Clean Tubers by Numbers as Shown by Three Replications and the Average for each Treatment

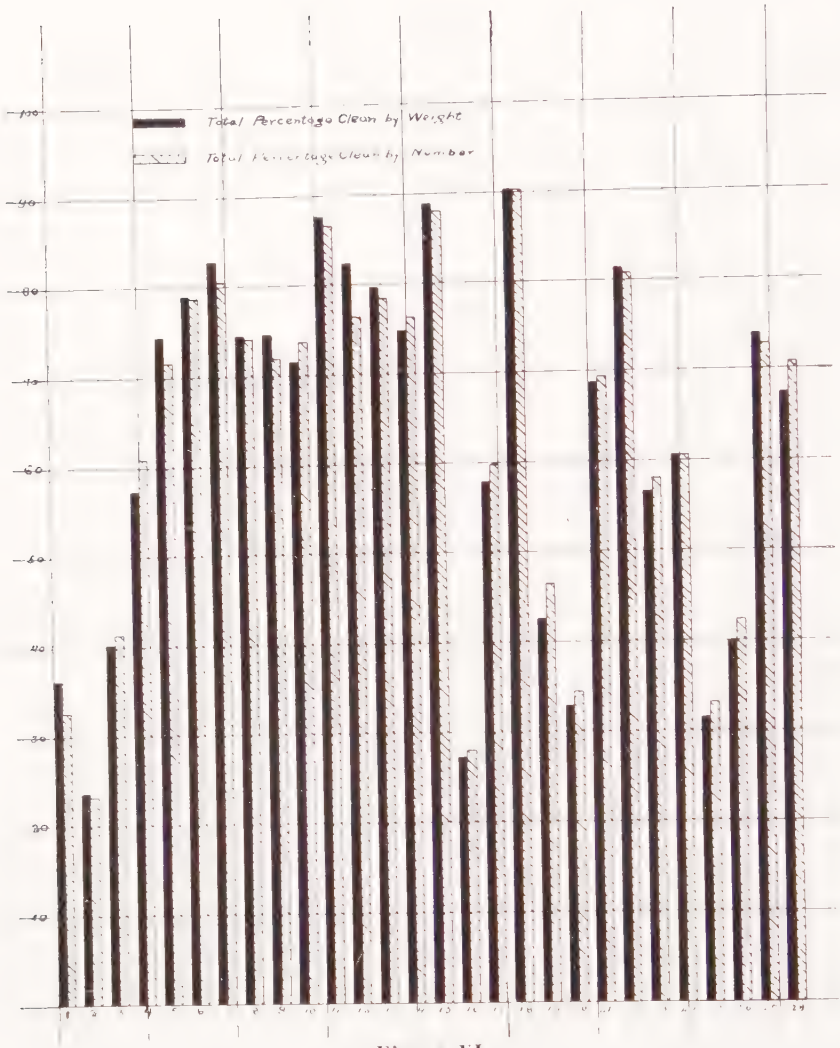


Figure VI

Results of Field Experiments for Rhizoctonia Control Showing the Comparison in Percentage of Control When Based on Weight and Number

The best control obtained at Moscow was with the Du Pont Dust No. 15 applied at the rate of 3 ounces per bushel, to presprinkled seed. Presprinkling increased the efficency of this particular mercuric dust from an average of 58.8 per cent to 90.3 per cent. None of the other dusts used gave as complete control as did mercuric chloride and some of the hot formalin treatments. In fact, the use of copper carbonate is to be guarded against as it not only gave poor control but also reduced germination of the seed after its use. Because of the havoc caused by gophers stand counts could not be made, as was anticipated.

Figures 4, 5 and 6 give in graphic form the percentages of control obtained at Moscow in 1924. Figure 4 gives the results showing the three replications and the averages when counts were based on weights. Figure 5 gives results when counts were based on number and figure 6 shows a comparison of the averages of figures 4 and 5. Weights in all cases are given in pounds. It will be noticed by reference to the figures that the results can be estimated with equal accuracy when either method of estimation is used. These results agree with those secured by Gilman and Melhus (8) in rather extensive tests carried on by them.

At Lewiston, under irrigation, very good results were obtained. There were several factors in favor of these trials, however. Irrigation water was not plentiful and accordingly had to be used sparingly; nor was

Table IX

Tests of Various Methods of Seed Treatment for the Control of Rhizoctonia of Potatoes under Irrigation. Lewiston, 1924

Treatment	Clean		Rhizoctonia		% Diseased		% Clean	
	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.
1. Check—(No treatment)	6.5	42	11	110	62.9	72.4	37.1	27.6
2. Formalin (1-120) 1½ hr. immersion presprinkled, covered 48 hrs.	15	160	3	34	16.7	17.5	83.3	82.5
3. Formalin (1-120) 50° C. 2 min.	18.5	200	2.5	22	11.9	9.9	88.1	90.1
4. Formalin (1-120) 50° C. 4 min.	15	156	0.5	9	3.0	5.5	97	94.5
5. Formalin (1-120) 55° C. 2 min.	22.25	208	1.25	13	5.1	5.9	94.9	94.1
6. Formalin (1-120) 55° C. 4 min.	22.5	189	4	30	15.1	14.2	84.9	85.8
7. Formalin (1-120) 50° C. 2 min. presprinkled, covered 48 hrs	30.5	220	2	18	6.2	7.6	93.8	92.4
8. Formalin (1-120) 50° C. 4 min. presprinkled, covered 48 hrs.	40.5	254	0	0	0	0	100	100
9. Check—(No treatment)	6.0	70	13	115	68.4	62.2	31.6	37.8
10. Formalin (1-120) 55° C. 2 min. presprinkled, covered 48 hrs.	18.75	195	0	0	0	0	100	100
11. Formalin (1-120) 55° C. 4 min presprinkled, covered 48 hrs.	16	194	0	0	0	0	100	100
12. Furfural (1-60) 10 min. presprinkled, covered 48 hrs.	13.5	168	0	0	0	0	100	100
13. Mercuric chloride, 1½ hr.	13.5	160	Trace	1	Trace	Trace	99.9	99.9
14. Mercuric chloride, 1½ hrs. presprinkled, covered 48 hrs.	15	185	Trace	1	Trace	Trace	99.9	99.9
15. Clean seed, mercuric chloride 1½ hrs. presprinkled, covered 48 hrs.	17.5	27	Trace	1	Trace	Trace	99.9	99.9
16. Clean seed—(No treatment)	16.5	165	2	20	10.8	10.8	89.2	89.2

there any rain. As a result of these two factors, the moisture content of the soil during the entire summer was lower compared with that at Moscow, also, the daily mean temperature at Lewiston was higher than it was at Moscow. Finally, by an examination of table IX, it will be noticed that the soil infection at Lewiston was quite negligible as compared to that at Moscow. In other words, the situation was quite ideal for determining the effect of treating the seed for the control of the organism carried by the seed. Almost absolute control in every case was obtained with the presprinkled series.

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PLATE 1

Figure 1. Large knobby sclerotia of Rhizoctonia solani on a Netted Gem potato. This is the type of sclerotia commonly found on potatoes grown without irrigation in the Pacific Northwest.

Figure 2. Diffuse type of sclerotia on green mountain potato.

Figure 3. Netted Gem potatoes showing the germination of sclerotia after having been dipped in water and placed in a moist chamber for 18 hours.

PLATE 1

Figure 2

Figure 3

PLATE 2

Figure 1. Four cultures of Rhizoctonia solani growing on potato dextrose agar. Note the variation in size and type of sclerotia.

Culture number 1 from Iowa.

Culutre number 2 from New York.

Culture numbers 3 and 4 from Utah.

Figure 2. The same four cultures as shown in figure 1, growing on oatmeal agar.

PLATE I

PLATE 3

Figure 1. Cultures of sclerotia of Rhizoctonia solani which were transferred from potato tubers after having been treated with corrosive sublimate 1 to 1000 for 1½ hours. Note the tufted growth in the center of the sclerotia.

Figure 2. The same as figure 1, enlarged.

Figure 3. Cultures of sclerotia of Rhizoctonia which were transferred from potato tubers after having been treated by the hot formaldehyde method.

Figure 3